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Ling et al.

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[45] **Aug. 20, 1974**

[54] **HIP JOINT PROSTHESES**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **3/1,** 128/92 C, 128/92 CA

[51] **Int. Cl.** **A61f 1/24**

[58] **Field of Search** ..... 128/92 CA, 92 C, 92 R, 128/92 BC; 3/1

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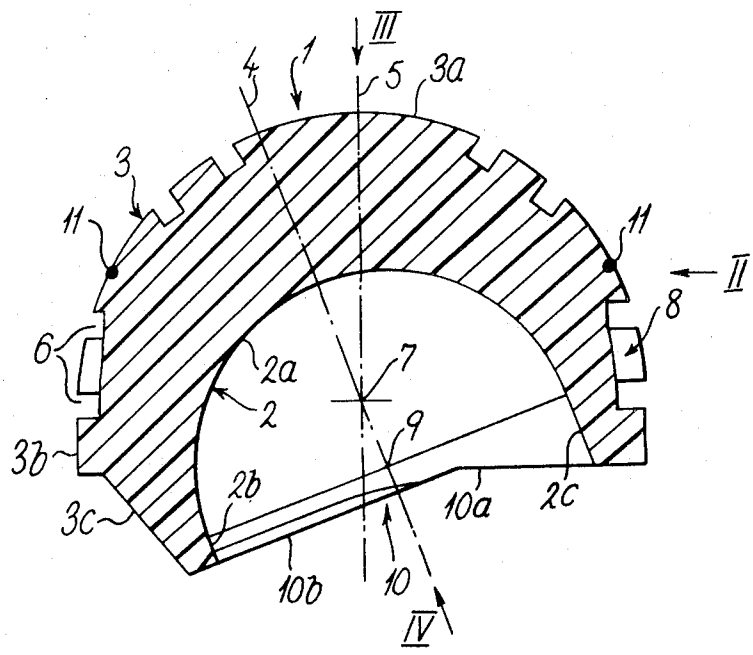
[57] **ABSTRACT**

A prosthetic hip cup is provided which is generally similar to the usual basically hemispherical form except that: the inner and outer surfaces have their spherical centres displaced, rather than coincident, to provide a greater wall thickness at the bottom of the cup compared to the side; and the axes of symmetry of the inner and outer surfaces are mutually angled to off-set the thickest part of the cup relative to the axis of the outer surface. This overall eccentricity provides greatest thickness in the main load bearing region of the cup, without introducing any significant disadvantage. An associated femoral device is also provided which is again generally similar to the usual ball headed tapered stem form except that: the ball is connected to the stem through a necked part without introducing a flange; and the stem is tapered in at least two different transverse directions. The absence of a flange simplifies the associated sectioning requirements for the femur, and the multiple tapering of the stem promotes better extrusion of gap-filling cement.

11 Claims, 11 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

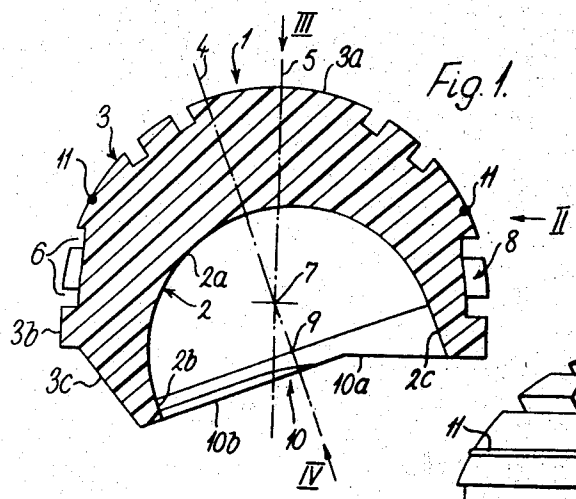


Fig. 2.

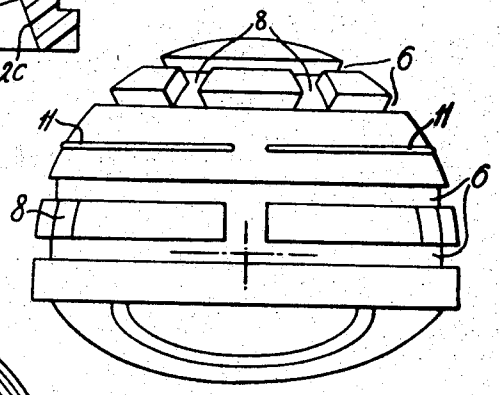


Fig. 3.

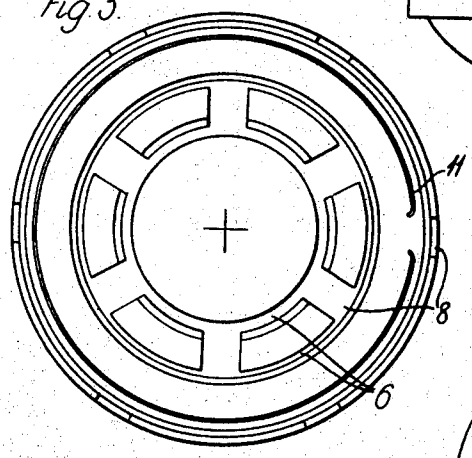
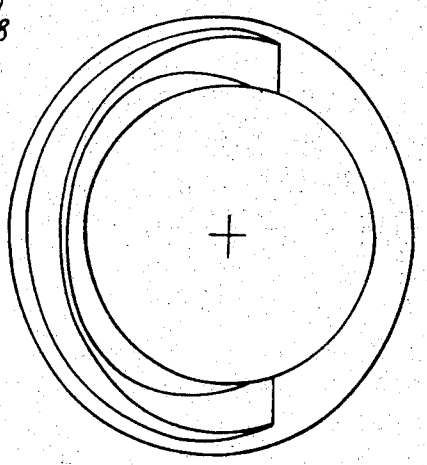


Fig. 4.



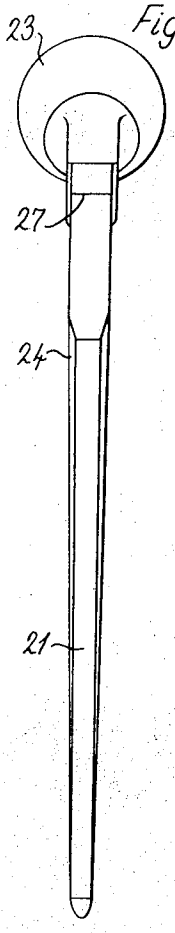


Fig. 6.

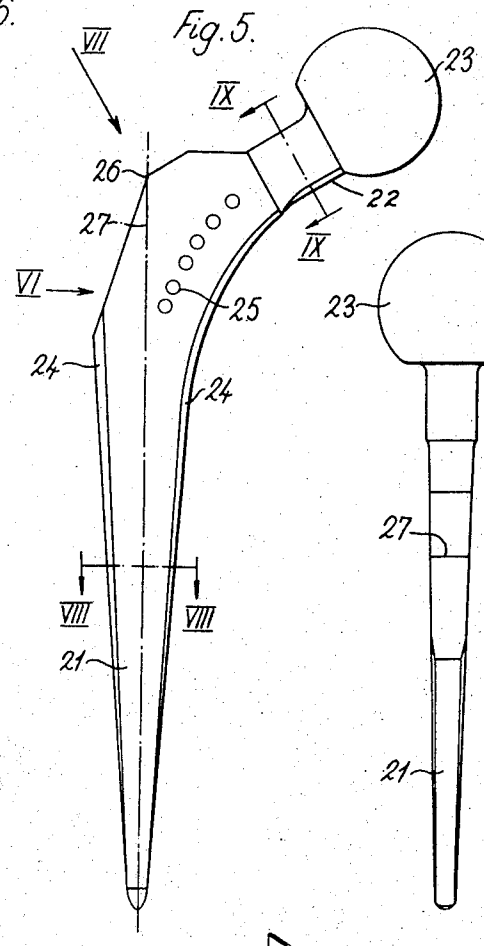


Fig. 5.

Fig. 7.

Fig. 8.

Fig. 9.

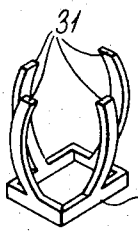


Fig. 10.

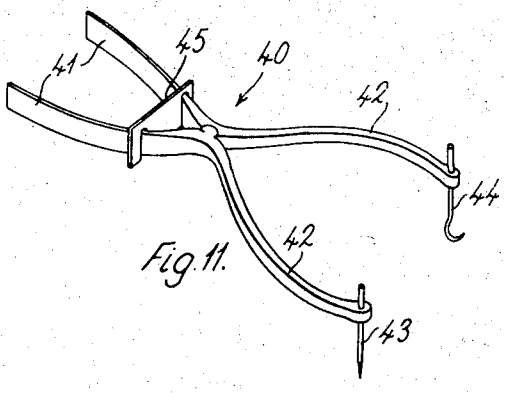


Fig. 11.

HIP JOINT PROSTHESES

The hip joint prostheses in more general current use involve an acetabular cup component and a femoral ball-headed component which co-operate to afford a ball-and-socket joint function. The bearing surface or socket of the cup is invariably of substantially hemispherical form complementary to the femoral component ball head with which it co-operates. Moreover the cup is normally of generally uniform radial thickness, the outer surface of the cup also being substantially hemispherical and concentric with the bearing surface, apart from the provision of grooving, ribs, studs, spikes or other formulations whereby the cup can be secured by way of cement or other means to serve as a prosthetic acetabular cavity.

However, the consideration leading to development of the present invention suggests that this basically hemispherical cup shaping is not satisfactory in all respects. More particularly, it is desirable that the outside diameter of the cup should not be too large, otherwise extensive reaming of the acetabulum is necessary to accommodate the cup. However, if the cup is not overlarge from this point of view, it will itself only accommodate a relatively small femoral component ball head and this is undesirable. In order to achieve stability of a relatively small femoral head in its cup, it is normally necessary to employ a particular form of surgical approach involving detachment and subsequent reattachment of the greater trochanter of the femur, and this does not meet with general favour among orthopaedic surgeons. Any attempt at a full and proper compromise between these factors as applied to a hemispherical cup will result in a wall thickness for the cup which is so low as to introduce a risk of early penetration of the cup by the head. This risk is more pronounced in relation to the central region of the cup, over the top of the head, where the general thrust and loading are at a maximum. Also, this risk is increased with the current trend to the use of plastic materials, such as high density polyethylene, for the cup in association with a metal femoral component, such a combination having at least equal, and normally better, frictional properties and, in addition, being cheaper in manufacture than a metal-to-metal combination.

An object of the present invention is to reduce the difficulties of this situation.

To this end the present invention provides, in one aspect thereof, a prosthetic acetabular device comprising a cup having an outer surface of substantially symmetrical form relative to a first axis therethrough, and an inner surface of substantially symmetrical form relative to a second axis therethrough, the inner surface being eccentrically disposed relative to the outer surface to provide a greater wall thickness in the closed end region of the cup compared to that in the rim region, and the two axes being mutually angled.

The proposed device has been developed with a view to fixation by the use of cement. In this connection, the cup preferably has generally spherical shaping over a major part of its outer surface in order to maximize the area to be engaged with the cement while minimizing the volume to be reamed from the acetabulum for a given size cup. In the same connection, it is preferred that the cup outer surface be grooved for purposes of keying the cement with the device. This avoids the deeper penetration of the cancellous bone which is otherwise necessary if long spike-like fixation members are employed.

Turning to consideration of the femoral component in a hip joint prosthesis, those used with acetabular components as discussed above normally have an elongate stem tapered towards one end, in one lateral direction, while being formed with notches, grooves, ribs or the like to assist keying of the cement with the stem. At its other end, the device is angled relative to the longitudinal axis of the stem, flanged and terminated with a ball-form head at the other end. The main body of the stem is intended for intramedullary fixation, commonly by the use of cement, this being terminated by engagement of the flange with a suitably sectioned face of the femoral neck to determine the final disposition of the head. However, the sectioning must be carried out before its correctness in respect of head positioning can be checked by use of the femoral component. At best, such a technique requires high skill and experience if secure fixation is to be achieved without comprising positioning of the head.

Another object of the present invention is to reduce the difficulties of this last situation.

To this end the present invention provides, in another aspect thereof, a prosthetic femoral device comprising a substantially spherically shaped head part joined by a necked part to an elongate stem, the longitudinal axis of said head part and necked part being angled relative to that of said stem, and said stem having noncircular cross-sectional shaping and being convergently tapered away from said necked part in at least two lateral directions and along a major longitudinal portion thereof.

The "double" taper of the stem of such a device enhances the extrusion of cement into the femur during insertion and is formed to make possible at least as efficient a fixation in terms of stability and load transfer as prior devices, but without the necessity for special cement-keying formations on the stem or the provision of a flange. The absence of a flange is equally advantageous in avoiding the necessity for sectioning of the femoral neck at a predetermined position or angle.

However it is desirable to provide an aid to correct vertical positioning of the proposed device to compensate for the absent flange which otherwise serves this role in the prior devices. Accordingly, it is proposed that the present device be used in association with a like device having a series of apertures therealong in the necked part and the adjacent stem region. This last device is to be used for test purposes, before application of cement to the femur, to gauge the appropriate depth for insertion of the femoral device to be secured. Thus, the test device can be supported at different depths by passing a pin through appropriate ones of the apertures. Having determined a correct depth for the device which is to be fitted, fitting can then proceed after suitably marking the device in question against the finally selected aperture of the test device.

More conveniently, for use of this last technique, the device to be fitted is preferably manufactured with markings having predetermined relation with the apertures of the test device.

A further consideration with the presently proposed femoral device is that efficient fixation of the stem will normally require the stem to be surrounded by a layer of cement which is not less than a certain thickness at any point. Certainly the stem should not contact the wall of bone in which it is to be secured, and ideally the

stem is centrally located with a uniform layer of cement therearound.

A further object of the present invention is to facilitate attainment of this requirement.

To this end the present invention provides, in a further aspect thereof, a spacer device for use with such a stem, comprising an annular base member having at least three spring members extending from mutually spaced positions around the base member, each of the spring members extending in directions having an outward radial component and a common axial component relative to the base member.

In the present instance, the base member of the spacer device is dimensioned to pass around and partway along the associated stem from the tip of the latter. The spacer device will be so disposed with its spring members directed away from the stem tip. Then, when the stem is implanted, the spring members will serve to space the stem from the surrounding bone in the desired manner, while still allowing extrusion of cement.

It will be appreciated that such a spacer device will find application with other prosthetic orthopaedic devices involving fixation by way of a tapered stem and cement.

In order that the above and other aspects and features of the present invention may be fully understood, the same will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is a cross-sectional view of one embodiment of a prosthetic acetabular device according to the invention,

FIGS. **2, 3** and **4** are respective views taken in the directions II, III and IV, of the device of FIG. **1,**

FIG. **5** illustrates in side elevation one embodiment of a prosthetic femoral device according to the invention,

FIGS. **6** and **7** respectively illustrate the device of FIG. **5** as viewed in the directions VI and VII,

FIGS. **8** and **9** are cross-sectional views taken respectively at VIII — VIII and IX — IX in FIG. **5,**

FIG. **10** illustrates one embodiment of a spacer device according to the invention, and

FIG. **11** illustrates a surgical tool suitable for use in association with the present invention.

The device of FIGS. **1** to **4** comprises a cup **1** having inner and outer surfaces **2** and **3** which are substantially symmetrical about respective axes **4** and **5.** The inner surface has a major portion **2***a* of hemispherical shaping which continues into a minor portion **2***b* of cylindrical shaping and which, in turn, continues into a further minor portion **2***c* of part-cylindrical, generally crescent shaping. The outer surface has major, minor and further minor portions **3***a*, **3***b* and **3***c* of basically corresponding shaping, except that the first two portions **3***a* and **3***b* have annular grooves **6** formed therein. The grooves **6** are disposed in respective radial planes relative to the axis **5** and they each penetrate the outer surface **3** in directions which are radial relative to the centre **7** of the hemispherical outer surface portion **3***a*. Groups of the grooves **6** are communicated by further grooves **8** which are directed orthogonally relative to the former.

The hemispherical inner surface **2***a* is centred on **9** and this centre is eccentrically located relative to the centre **7** to provide greater wall thickness for the closed end of the cup compared to that in the region of its rim. Also, the axes **4** and **5** are mutually inclined so that the thicker wall zone of the cup is off-set relative to the axis **4.** This off-set takes account of the finding that the maximum likelihood of penetration by an associated femoral device will occur at a position within a range of about 12° – 15° from the axis **5** in the direction of axis **4,** while at the same time enhancing the stability of an associated femoral device head in the cup. This dual purpose is served in the illustrated cup by a mutual angling of about 20° between the axes **4** and **5.**

It is also useful to note at this point that the axis **5** is not vertical when the cup is implanted, but is inclined by clockwise rotation of FIG. **1** while the associated femoral device extends downwardly therefrom, first to the left and then generally vertically. More particularly, it is preferred that the axis **5** assumes an angle of about 40° with the vertical when implanted, this orientation being found surgically advantageous in facilitating insertion.

Since the inner surface **2** will, as with other acetabular devices, closely approximate to a hemispherical shaping in the main part, the mutual angling referred to above also gives rise to the part-cylindrical crescent shaped portion **3***c* of the outer surface **3.** This can be expressed in another way by noting that the rim of the cup will be chamfered relative to the outer surface axis **5.** In any event, this configuration is advantageous since the portion **3***c* and associated rim chamfer can be located to afford full abduction of the femur before the femoral neck abuts the cup, while still affording full engagement of the femoral head in the cup.

Consideration of FIG. **1** in fact shows the rim of the cup to have, in a currently preferred form, a compound chamfer **10** composed of one planar portion **10***a* radial to the axis **4** and another planar portion **10***b* radial to the axis **5.**

A remaining feature of the illustrated cup is the provision of marker wire **11** engaged in a groove around the cup outer surface. This wire is chosen to be detectable by x-ray examination and thereby indicates the relative positions of the cup and femoral head after implantation. The marker is preferably disposed in a plane tangential to the cup inner surface at the closed end region so as to more readily indicate penetration of the cup by the femoral head.

Normally the marker will be of a suitable metal, such as stainless steel, while the cup is preferably made of high density polyethylene.

Turning to consideration of the illustrated femoral device, this is seen to comprise a stem **21** convergently tapered towards one end and joined at its other end through a necked portion **22** to a spherically shaped head part **23,** the longitudinal axis of the necked portion and head part being angled relative to that of the stem.

The stem **21** is of rounded-corner rectangular cross-sectional form and is tapered in both of the lateral directions which correspond to the axes of the section form. The tapering is of a higher degree in the lateral direction which corresponds to larger rectangular dimension, so that the overall tapering terminates with a generally square cross-sectional form.

In any event, as discussed above, this double tapering enhances the extrusion of cement caused by penetration of the stem thereinto during fixation, while the flat

surfaces arising from the choice of cross-sectional form reduce any tendency for rotation.

A feature of the rounding of the stem corners is that this rounding, or effective chamfering is also tapered longitudinally of the stem, but in the opposite sense to the main body of the stem in order to facilitate extrusion of cement laterally around the stem in its thicker regions.

It is also useful to consider the remaining parts of the femoral device since these are additionally advantageous.

Thus, the stem is angled directly into the necked portion **22** without any provision of a flange. It has been mentioned above that the commonly provided flange on a prosthetic device plays no significant part in terms of enhancing fixation. Accordingly, the omission of a flange is advantageous in simplifying the device and so rendering it more economic in manufacture. An additional and perhaps more important advantage is that positioning of the device during fixation is not open to compromise by the need for special sectioning of the femoral neck.

In connection with this question of positioning, it is proposed that use of the illustrated device involves a similar "test" device. The test device will differ by the provision of apertures along its stem whereby it can be located, before insertion of cement, in different positions as regards depth of penetration. These different locations can be achieved by passing a pin through different ones of the apertures to span the femoral neck and so temporarily support the test device. In this way, a guide to the optimum location of the device to be implanted can be obtained vis-a-vis the associated acetabular cavity, be it natural or prosthetic. This technique can involve marking of a device to be fixed against the finally chosen aperture of the test device or, more conveniently, by pre-marking the former device during manufacture to provide visible markings related with the apertures of the test device. Such markings are denoted at **25** in FIG. **5.**

Further assistance in positioning of the device during insertion is afforded by arranging the angular apex **26,** towards the top of the stem, to intersect the longitudinal axis of symmetry **27** of the main body of the stem. This axis should be aligned with the longitudinal axis of the femur and the afore-mentioned arrangement assists the surgeon's visual assessment of when the desired positioning is attained.

A further advantageous feature is found in the asymmetrical or off-set nature of the necked portion relative to the head part. This feature is not essential but is employed here for benefit in association with a prosthetic acetabular device such as that also illustrated and which is intended to be fixed at a lesser degree of abduction than is more usually the case. In these last circumstances, a greater degree of flexion and abduction is afforded by the presently proposed off-set arrangement compared to an equivalent, but symmetrical neck and head part.

The form and function of the spacer device of FIG. **10** is largely self-explanatory from the illustration and the earlier description. It is probably sufficient to note that the annular base member **30** of the device is generally rectangular for association with a stem such as that in FIGS. **5** to **8.** Similarly, there are four spring members **31** extending from the central regions of respective sides of the base member to act in association with corresponding sides of the relevant stem.

Lastly reference has been made to a surgical tool suitable for use in association with the present invention. More particularly, the invention has been developed with a view to insertion by way of the so-called Southern or Posterior Approach. This approach can involve difficulty in the required separation of the femur and acetabulum such that the surgeon must normally be assisted simply to retain the operation site exposed.

The tool of FIG. **11** reduces this difficulty. The tool takes the form of a pair of inverse tongs **40** whereby closure of the handles **41** opens the arms **42.** The free end of one arm carries a pin **43** for insertion into the ischium behind the sciatic nerve and the other arm carries a hook **44** for engagement into the surface of the femoral neck. The pin and hook can be so engaged, with the tool handles open, that subsequent closure of the handles separates the femur from the acetabulum while rotating the femur to expose the head. The handles can then be held in the closed position by a suitable clamp or bracket **45.**

We claim:

1. A prosthetic acetabular device comprising a cup having an inner surface and an outer surface, which surfaces are of similar form including a substantially hemispherical major surface portion continuing into a crescent-shaped minor portion, said major surface portions being mutually eccentrically disposed by relative translation of their respective spherical centres and mutual angling of their respective radial axes of symmetry, and said crescent-shaped minor portions being disposed in mutually opposed manner and each being intersected in similar medial manner by the plane passing through said radial axes.

2. A device according to claim **1** wherein each of said inner and outer surfaces comprises a cylindrical minor surface portion located between the respective hemispherical and crescent-shaped surface portions as a smooth continuation of the first of these last-mentioned portions.

3. A device according to claim **1** wherein said outer surface is grooved by the provision of a plurality of first grooves of annular form disposed in transverse radial planes relative to said outer surface axis of symmetry, and a plurality of second grooves of part annular form disposed orthogonally relative to said first grooves to intercommunicate at least some of said first grooves.

4. A device according to claim **1** comprising a radio-opaque member of annular form connected around said cup in a plane substantially tangential to said inner surface at the closed end region thereof.

5. A device according to claim **1** in combination with a prosthetic femoral device comprising a substantially spherically shaped head part received in mutual bearing engagement with the inner surface of said cup and joined by a necked part to an elongate stem, the longitudinal direction of said head part and necked part being angled relative to that of said stem, said stem having noncircular cross-sectional shaping, and said stem being convergently tapered away from said necked part in at least two lateral directions and along a major longitudinal portion thereof.

6. A device according to claim **5** wherein said stem is of generally rectangular cross-sectional form with the corners of such form chamfered along a major longitu-

dinal portion of said stem and to a progressively increasing depth therealong towards said necked portion.

7. A device according to claim **5** wherein said head part is off-set relative to said necked part in a direction away from that of the included angle of said necked part and said stem.

8. A device according to claim **5** wherein a major portion of said stem remote from said necked part is of substantially symmetrical form relative to a longitudinal axis through the former, and the remaining part of said stem has a generally chamfered surface remote from the included angle between said stem and necked part, which chamfered surface defines a visibly detectable boundary intersected by said longitudinal axis.

9. A device according to claim **5** wherein said stem is visibly marked to define a succession of predetermined discrete positions extending longitudinally therealong from a first position adjacent said necked part.

10. A device according to claim **5** in combination with a spacer device comprising an annular base member having at least three spring members extending from mutually spaced positions around said base member, said base member being engaged around and part way along said stem, and each of said spring members extending in directions having an outward radial component and a common axial component relative to said base member.

11. A prosthetic acetabular device comprising: a cup having an inner surface and an outer surface; said inner surface including a substantially hemispherical major surface portion continuing smoothly into a substantially cylindrical minor surface portion, which latter portion itself continues smoothly into a crescent-shaped further minor surface portion; and said inner and outer surfaces having an eccentric relationship to define a varying thickness for said cup, with a region of maximum thickness being intersected by the radial axis of symmetry of said major surface portion.

* * * * *